TECHNICAL APPENDIX D

HYDRAULIC DESIGN

**In Support of Section 1135
Aquatic Habitat Restoration at
Santa Ana Pueblo, New Mexico**

Prepared for

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D. HYDRAULIC DESIGN

The overbank lowering restoration plan is intended to increase the frequency of overbank inundation and increase habitat availability for native fish and wildlife. A critical component of the overbank lowering is the construction of the GRFs designed under a separate Section 1135 project. When put together, the overall restoration plan includes two gradient restoration facilities (GRF), a downstream bed sill and overbank lowering as illustrated on **Plate D.1**. The following sections describe the design considerations for the overbank lowering features and provide a 35% basis of design and preliminary quantity estimates. The hydraulic design of the GRFs and downstream bed sill are documented in the technical appendices (Appendix D) for that project.

D.1 Overbank Lowering

Overbank lowering will provide benefits to habitat by increasing the amount of inundation and preferred habitat availability at higher frequency discharges. Overbank lowering will be accomplished by excavation of material from the sand bars in the lower Santa Ana Reach. Six sand bars were identified for overbank lowering within the lower Santa Ana reach as shown on Plate D.1. The depth of lowering for each bar was designated using results from the 2-dimensional hydraulic model as described in Technical Appendix C – Hydraulics and shown in **Table D.1**.

The overbank lowering depths were selected to provide approximately 0.5 ft of inundation for the 2-year flood. The volume of material designated for removal from the six sand bars in the overbanks is approximately 170,600 yd^3 (226,000 tons) of in-place material. A breakdown of the quantities for each sand bar is listed on Plate D.1.

Table D.1. Overbank Lowering Depths for the Designated Sand Bars in the Lower Santa Ana Reach.

Sand Bar #	Overbank Lowering Depth (ft)
1	2.0
2	1.5
3	1.0/1.5*
4	2.0
5	1.5
6	2.2

*Depths of lowering for bar #3 are 1.0 ft at the upstream end and 1.5 ft at the downstream end.

A comparison of the overbank lowering quantities and sediment load/degradation in the Santa Ana Reach was made to investigate the potential for distributing this material into the Santa Ana reach. The degradation analysis presented in Technical Appendix A - Geomorphology provided a sediment budget and degradation rates for the Santa Ana Reach following construction of Cochiti Dam. The analysis indicated that the Santa Ana reach experienced in excess of 130,000 tons of degradation per year from 1975 to 1995 and somewhat less degradation was observed from 1995 to 1999. The reduced rates from 1995 to 1999 were related to reduced flows on the Rio Grande (see Figure A.15 in Appendix A).

The degradation rates were compared to overbank lowering values to estimate the amount of degradation that would be replaced if the overbank material were deposited in the Santa Ana reach. In addition to the overbank lowering recommended for the current design, it was previously estimated that the upstream USBR restoration project, near the Rio Jemez confluence would deliver as much as 900,000 tons of material to the lower reach. However, this estimate has not been re-evaluated since the construction of the USBR restoration projects in 2003 – 2004. Average degradation values and the yearly equivalent of material from the overbank lowering are presented in **Table D.2**.

Table D.2. Comparison of Overbank Lowering Sediment Quantities and Yearly Degradation Rates for the Santa Ana Reach.

Overbank Lowering USBR + USACE project (tons)	Computed Degradation Rates (tons/year) 1975 – 1999 Average	Amount of Degradation Replaced
1,270,000	126,000	10 years

The comparison indicates that ten years of material would be replaced if the overbank material were deposited and retained in the Santa Ana reach channel. The contribution from the USBR project represents approximately seven years of degradation and the design associated with this report represents approximately three years. Since the future degradation is dependent on future hydrology it is difficult to estimate the time required to distribute the overbank material, but it is likely in the 10-year range. As mentioned previously, there is a potential for minor redeposition of fines on the lowered overbank areas, but redeposition of significant amounts of sand and gravel bedload is not anticipated.

The combined amount of sediment from overbank lowering and the USBR project upstream could alter the hydraulics in the lower reach. Therefore, it is recommended to monitor the distribution of sediment received from the USBR project upstream and evaluate the feasibility for introducing the overbank lowering material into the channel at a later time. The quantities from the USBR project are estimates from a construction schedule generated prior to final design. A reassessment of disposal of the overbank lowering material could be made following reception of the final USBR quantities.

D.2 Refined Quantities

Estimates of quantities for the overbank lowering were computed for cost estimating purposes. Preliminary quantities used for the incremental cost analysis are provided in Technical Appendix C - Hydraulics. Overbank lowering includes quantities for excavation and clearing and grubbing. Relocation (haul) quantities for these materials were not computed. The design quantities are listed in **Table D.3** and shown on Plate D.1.

Table D.3. Restoration Feature Construction Quantities.

Restoration Feature	Clearing and Grubbing (ac)	Overbank Excavation (yd^3)
Overbank Lowering	15.6	170,588

The construction quantities were based on topographic data as of Spring 2005. Construction of restoration works upstream and continued degradation may alter the channel and overbank geometry in the lower Santa Ana reach. The magnitude of these changes will depend on the distribution of sediment delivered from upstream and the time of construction in the lower reach. This may affect construction quantities. Therefore, prior to construction the channel and overbank geometry should be compared to the geometry utilized for this design.

D.3 Operation, Maintenance, and Inspection

The lowered overbank areas are designed to increase preferred habitat availability in the lower Santa Ana Reach on the Rio Grande. The performance of the features could be impacted by changes in their specified design parameters resulting from construction or other factors following construction. Therefore, the design will require close supervision of construction and periodic inspection to ensure that the facilities are properly maintained. Conformance to the specified design will be determined from post-construction inspection, and periodic inspection/maintenance activities will be required to ensure long term performance of the restoration features.

D.3.1 Post-Construction Inspection

Inspection of the overbank lowering will be required immediately following completion of construction to ensure that the project was built to the design specifications. This will include a topographic survey in the lower Santa Ana reach. It is recommended that a general lower reach survey be conducted to verify construction of overbank lowering and to provide comparison sections for future periodic inspections. The general lower reach survey should include approximately 10 to 15 cross sections distributed throughout the lower reach.

D.3.2 Operation and Maintenance Inspections

It is not anticipated that there will be any maintenance costs associated with the overbank lowering. However, periodic inspections of the lowered areas should be conducted to verify these surfaces are providing the anticipated increase in favorable habitat.

Hydraulic Monitoring

The lowered overbank areas have been designed to create favorable velocity and depth conditions for fish habitat. Hydraulic conditions within these areas should be monitored to determine whether the design criteria are being met. Water depths and velocities should be measured at the cross section lines established for inspection. The measurements should be compared to observed and simulated data. Hydraulic monitoring should be conducted concurrently with the general lower reach survey during the first five years of operation and, subsequently, as needed to ensure that changes detected by inspection do not result in adverse hydraulic conditions. An effort should be made to schedule hydraulic measurement to encompass a range of flows each year during the initial 5-year monitoring period.

Planform Monitoring/Bank Stabilization Maintenance

The alignment of the channel through the reach may influence sedimentation, bank stability and flow patterns. Changes in river planform or bank migration should be documented through periodic aerial photography and cross section surveys. It is recommended that aerial photography at 5-year intervals be obtained to identify significant changes. In addition, bankline migration/failure can be identified using comparative cross sections along monumented transects. Therefore, general lower reach surveys should be conducted on an annual basis for the first five years following construction and at a 2- to 5-year frequency thereafter. Dramatic changes can occur during high-flow events, and in such cases aerial photographic documentation and/or cross section surveys should be acquired immediately following large floods.

D.3.3 O&M Estimated Costs

The inspection and maintenance actives described previously should be considered in the overall project costs. Estimates of annual costs associated with each of the O&M activities are provided in **Table D.4**.

The cost analysis indicates that the annual operation and maintenance costs could be as much as $7,500 per year or $375,000 for the total project life. Inflation and interest were not include in the estimate. It is anticipated that some of these costs could be shared between the U.S. Army Corps of Engineers, U.S. Bureau of Reclamation, and the Pueblo of Santa Ana.

Table D.4. O&M Schedule and Cost Estimate.

O&M Activity	Frequency of O&M Activity	Estimated Number of Activities in Project Life	Cost Estimate per Activity ($)	Annual O&M Cost Estimate ($)
Visual Inspection	Yearly	50	1,000	1,000
General Lower Reach Survey/ Hydraulic Monitoring	Yearly for the first 5 years and every 2 – 5 years thereafter	15	20,000	6,000
Aerial Photography	Every 5 years	10	2,500	500
			Total Annual Cost	7,500

TECHNICAL APPENDIX E

WETLAND / BOSQUE RESTORATION FEASIBILITY STUDY

for the

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EXECUTIVE SUMMARY

The Santa Ana Pueblo has embarked on an aggressive bosque restoration project on Tribal lands along the Middle Rio Grande. The bosque forest, currently overrun by salt cedar (*Tamarix* sp.) and Russian olive (*Elaeagnus angustifolia*), is being restored to native bosque and wetland habitats. This report investigates the feasibility of restoring a sustainable bosque-wetland complex on a site of approximately 17 acres on the Santa Ana Pueblo reservation.

Five primary goals were established for this project:

1. Restore historic wetland habitats that optimize wildlife values.
2. Be self-sustaining without the need for long-term maintenance.
3. Minimize created mosquito habitat.
4. Minimize hazards to resort guests.
5. Be cost effective in terms of habitat created per dollar spent.

Historically, overbank events were fairly common along the Middle Rio Grande. Flooding scoured bare ground and provided moist areas for seedling germination, perpetuating the bosque. Construction of dams altered the historic flood-flow timing and duration, and sediment dynamics. The river has degraded through this section, and overbank flows no longer occur.

Historic and current hydrologic, soil, and vegetative conditions point to an area historically supporting a bosque community dominated by cottonwood (*Populus* spp.), willows (*Salix* spp.), and other native riparian shrub species. On-site soils and the historic hydrologic regime do not indicate the past presence of open-water habitats or large areas of emergent wetland.

To address degradation of the Santa Ana Reach, an aggressive program of installing gradient control structures across the Rio Grande has been initiated. Once installed, these structures will not result in increased surface water elevations on the Rio Grande, and an increase in groundwater elevations in the 17-acre wetland restoration project area is unlikely. Overbank flooding of the site is also not expected.

The wetland restoration project site is a 17-acre site on the Santa Ana Pueblo reservation, immediately west of the Rio Grande. Two types of wetland complexes were studied for this project, each with three alternative designs. The first wetland complex is an open-water dominated wetland with ponds fringed with emergent and shrub vegetation (*open water wetland complex*). The second wetland complex is a riparian shrub wetland without an open water component (*shrub wetland complex*).

Two types of wetland complexes were studied for this project, each with three alternative designs. The three *open water wetland* designs include: 1) a minimum wetland creation effort (about five acres), 2) maximum wetland creation effort (about ten acres), and 3) maximum wetland creation effort with backwater habitat added. For these designs, a series of ponds would be created in north to south swale-like settings interspersed with emergent and shrub habitats. The remainder of the site would be restored to a bosque plant community.

Three *shrub wetland* designs mimicking the open water design scenarios were also studied. These include: 1) a minimum shrub wetland creation effort (about five acres), 2) maximum shrub creation effort (about ten acres), and 3) maximum shrub wetland creation with backwater habitat added. With these designs the shrub habitats would be created in north to south swale-like settings interspersed with restored bosque habitat.

Plant species proposed for use in the restoration effort are native to the Middle Rio Grande region, adapted to riparian and wetland conditions. Pole cuttings would be used for Fremont cottonwood (*Populus fremontii*) and black willow (*Salix nigra*). Whip cuttings would be used for coyote willow (*Salix exigua*). Seepwillow (*Baccharis glutinosa*), false indigobush (*Amorpa fruticosa* var. *occidentalis*), skunk-bush sumac (*Rhus aromatica* var. *flabelliformis*), New Mexico olive (*Forestiera neomexicana*), and wolfberry (*Lycium andersonii*) would be planted as containerized shrubs. While cottonwood cuttings would be widely spaced, shrub species would be planted in clumps to mimic the dense thickets often formed by the species.

A drip irrigation system is recommended for this project rather than an overhead impact system. The main benefit of a drip system is the direct application of water to individual plants, which reduces the amount of water required and lessens the potential for developing a weed problem.

Construction cost estimates range from $300,500 for the minimum open water design to $513,430 for the ten-acre open water wetland design with backwater habitat. For the shrub wetlands, the cost estimate ranged from $200,420 for the minimum effort to $273,310 for the ten-acre design with added backwater habitat. The amount of excavation required to create the various habitat configurations accounts for the construction cost differences. Approximately 124,000 cubic yards of material would be excavated for the ten-acre open water wetland with backwater habitat, costing a little over $372,000. Only 47,000 cubic yards of material would be excavated to create the ten-acre shrub wetland with backwater habitat, costing a little over $141,000.

Shrub wetland design scenario three, which restores 11.5 acres of shrub wetland and 5.5 acres of bosque habitat and creates 0.7 acres of backwater habitat, is the only scenario of the six studied that meets or partially meets all project goals and objectives. The estimated cost for this design scenario is $273,310. It does not create a mosquito problem, nor does it expose the Santa Ana Pueblo or the resort guests to increased risk. While it does not optimize habitat types relative to the open water designs, it does restore a native wetland type currently lacking in the immediate vicinity in a cost-effective manner. Shrub wetland scenario three is the recommended restoration design. This design could very easily be expanded beyond the 17-acre site currently under consideration. The Santa Ana Pueblo own a considerable amount of land with similar characteristics to those described in this report that would be suitable for this kind of restoration effort.

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INTRODUCTION

The Santa Ana Pueblo has embarked on an aggressive bosque restoration project on Tribal lands along the Middle Rio Grande. Areas of historic cottonwood (*Populus* spp.) forest (bosque) have been overrun by non-native and extremely aggressive salt cedar (*Tamarix* sp.) and Russian olive (*Elaeagnus angustifolia*). This report investigates the feasibility of restoring a sustainable bosque-wetland complex on a site of approximately 17 acres on the Santa Ana Pueblo reservation.

PROJECT GOALS

The goal of this project is to restore the site to include wetlands that historically occurred along the Middle Rio Grande that have been degraded or lost as the result of dams, water diversions, and draining. Five primary goals were established for this project:

1. Restore historic wetland habitats that optimize wildlife values.
2. Be self-sustaining without the need for long-term maintenance.
3. Minimize created mosquito habitat.
4. Minimize hazards to nearby resort guests.
5. Be cost effective in terms of habitat created per dollar spent.

Additionally, the wetland complex could be an amenity to the resort and could provide recreational and educational opportunities to resort visitors.

While not a major goal of this project, there is also an opportunity to create backwater habitat for the silvery minnow, a fish species listed as endangered under the federal Endangered Species Act.

HISTORIC CONDITIONS

An assessment of historic conditions compared to the present day provides insight on the feasibility of restoring historic conditions and habitats.

HYDROLOGY

Middle Rio Grande flows were characterized by an annual hydrograph typical of the desert southwest. Peak flows were in May and June, with low flows in late fall through late spring. Overbank events were fairly common. Flooding scoured bare ground and provided moist areas for seedling germination. The river meandered, eroding its banks and depositing fresh sediment, creating new channel braids and gradients for bosque vegetation (Taylor et al. 1998). The river was wide and shallow relative to current conditions (Ayres 1999).

Construction of flood control dams altered the historic flood-flow discharge, duration, and sediment dynamics (Taylor et al. 1998). Since the closure of Cochiti Dam in 1975, the Santa Ana reach has narrowed and deepened, and overbank flooding no longer occurs (Ayres 1999). The placement of Kellner jetty jacks in the 1950s (Scurlock 1998) and sediment retention in behind dams has had the dual effect of raising the surrounding floodplain and degrading the riverbed through the project area (DeRagon pers. comm 1999). The jacks created large areas of moist alluvium that were subsequently colonized by native and exotic trees and shrubs (Crawford et. al. 1993, cited in Scurlock 1998).

The restoration site is surrounded on three sides by an historic high flow channel. Aerial photographs and site topography confirm that many such channels historically occurred in the area.

VEGETATION

For as long as two million yeas, a cottonwood-dominated bosque existed along the Middle Rio Grande (Scurlock 1998). When the Spaniards arrived in the 16th century, the banks, bars, and adjacent floodplain were vegetated with valley cottonwood (*Populus deltoides* var. *wislizeni*) over a willow- (*Salix* spp.) and saltgrass- (*Distichilis spicata*) dominated understory. Other species associated with the bosque included New Mexico olive (*Forsestiera pubescens* var. *pubescens*), baccharis (*Baccharis wrightii*), false indigo bush (*Amorpha fruticosa*), and wolfberry (*Lycium andersonii*) (Scurlock 1998).

Cattails (*Typha* spp.), sedges (*Carex* spp.), spikerush (*Eleocharis* sp.), rushes (*Juncus* spp.), scouring rush (*Equisetum hyemale*), buttercup (*Ranunculus cymbalaria*), pepperwort (*Marsilea vestita* spp. *vestita*), mosquito fern (*Azolla mexicana*), carrizo (*Phragmites australis*), and yerba mansa (*Anemopsis californica*) grew around wetlands or areas with a high water table (Scurlock 1998). Deep water habitats supported pondweed (*Lemna minor*), milfoil (*Myriophyllum spicatum*), and hornwort (*Ceratophyllum demersum*) (Scurlock 1998).

A detailed botanical survey of the Middle Rio Grande Valley was conducted by Watson (1912, cited in Scurlock 1998). He described two major floristic associations in the Rio Grande floodplain: nearly pure stands of cottonwood with a scattering of willows, *Baccharis*, *Senna*, and sedge, and wet meadow community of sedge, yerba mansa, *Baccharis*, common sunflower (*Helianthus annuus*), and canaigre (*Rumex* sp.). Neither salt cedar nor Russian olive were identified as components of the bosque, but salt cedar was mentioned as being planted in Albuquerque as an ornamental. Both species were recorded by Van Cleave in the early 1930 (Van Cleave 1935, cited in Scurlock 1998), who was studying plant community changes due to drainage projects undertaken by the Middle Rio Grande Conservancy District. These drainage projects resulted in the virtual loss of lakes, swamps, and marshes along the Middle Rio Grande (Scurlock 1998).

Recent studies have demonstrated that historically-dominant *Populus* and *Salix* woodlands are failing to regenerate on dammed, low-gradient meandering river types (i.e., Middle Rio Grande). This, and the drier overbank conditions, have led to large increases in exotic arboreal species, particularly salt cedar (Johnson 1998).

CURRENT CONDITIONS

HYDROLOGY

Hydrology of the site has been the subject of studies carried out by the Santa Ana Pueblo (1999) and Ayres Associates (1999). The Natural Resources staff of the Santa Ana Pueblo has monitored groundwater wells in the vicinity of the project for three years. Groundwater wells were installed in the restoration site in 1999. The Ayres study modeled the hydrology and hydraulics of the Rio Grande with respect to current conditions and expected changes following the installation of gradient control structures across the Rio Grande.

The Santa Ana Pueblo has documented groundwater depths at the study site (wells 11 and 12) varying from approximately five feet below the surface in May to as deep as seven to nine feet below the surface in March and April. Groundwater depths were measured at 5.0 to 8.5 feet below the soil surface in July and August. The high water table elevations (May) occurred during mean daily flows on the Rio Grande of approximately 3,500-4,300 cubic feet per second (cfs), but spikes of over 6,000 cfs also occur at this time. Low water table elevations (March and April) were measured when flow was estimated to be less than 1,000 cfs.

Of particular interest in the Ayres report (1999) are the lack of potential effects that installation of the gradient control structures would have on groundwater elevations and on reestablishing overbank flooding of the project site. According to Ayres, installation of the structures will not result in increased surface water elevations on the Rio Grande through the wetland restoration project reach. Therefore, an increase in groundwater elevations in the project area is unlikely. The Ayres model also indicates that overbank flooding of the restoration site would not be expected up to a flow of 10,000 cfs, the largest flow modeled.

SOILS

According to information provided by the Natural Resource Conservation Service (NRCS), the restoration site is mapped as Peralta loam, one to three percent slopes unprotected (mapping unit 835). Soil studies conducted by the Santa Ana Pueblo, however, would indicate that the on-site soil is Trail loam (mapping unit 830) rather than the mapped Peralta loam. The NRCS has mapped a large area of Trail loam immediately north of the restoration site (NRCS 1999).

Peralta Loam

The Peralta series (mapping unit 835) consists of very deep, somewhat poorly drained, moderately permeable soils that formed in mixed alluvium on flood plains. Slopes are zero to three percent. Included in mapped units of Peralta are areas of Gilco, Aga, and trail soils that can constitute 15 percent of the mapped unit. Peralta loam is classified as a coarse-loamy, mixed, calcareous, mesic Typic Ustifluvents (NRCS 1999). Peralta soils are not listed as hydric by the National Technical Committee for Hydric Soils (NTCHS) (NTCHS 1991).

According to the NRCS (1999), the potential natural plant community on this unit is characterized by cottonwood, willows, New Mexico olive, and mesquite (*Prosopis* sp.).

The soil is moist in some or all parts from March to October, and is subject to a water table at depths of 24 to 36 inches during this period. The depth to redoximorphic features (mottles) which is from 12 to 30 inches, indicates the depth to the fluctuating water table and seasonally saturated soils above the water table (NRCS 1999).

Dick-Peddie et al. (1987), in a study that correlated soil to vegetation types along the riparian zones of the Gila and San Francisco rivers, reported that mesic Typic Ustifluvent soils were commonly found along lower terraces of these two rivers. The dominant plant species found in this soil type and their wetland indicator status are provided in Table 1. Obligate riparian species are those species normally restricted to riparian or riparian-like habitat (Dick-Peddie et al. 1987).

Table 1 – Dominant Plant Species Correlated with Typic Ustifluvents

Scientific Name	Common Name	Wetland Indicator Status**	Obligate Riparian?
*Populus fremontii**	Fremont cottonwood	FACW	Yes
*Salix gooddingii**	Goodding willow	OBL	Yes
Platanus wrightii	plane tree	FACW -	Yes
Juglans major	Arizona walnut	FACW -	Yes
*Baccharis glutinosa**	seepwillow	FACW	Yes
Celtis reticulata	netleaf hackberry	FACU	Yes
*Melilotus alba**	white sweet clover	FACU +	No
*Ambrosia artemisifolia**	bursage	FACU	No

* Species common to the Middle Rio Grande

**Wetland Indicator Status Definitions are provided in Appendix A

Source: Dick-Peddie et al. 1987.

Trail Loam

Trail loam (mapping unit 830) consists of very deep, moderately well-drained soils that formed in stratified alluvium, dominantly from sandstone. This soil occurs on the Rio Grande floodplain, low terraces, and alluvial fans that have slopes of zero to eight percent. Trail soils are neither saline nor sodic. The soil occurs in thin strata of sandy loam, fine sandy loam, very fine sandy loam, loam, and silt loam. Runoff is slow and the permeability is moderately rapid. Included in mapped areas of Trail are small areas of Peralta, Gilco, and Aga soils that can make up to 30 percent of a mapped unit. Trail soils are classified as sandy, mixed, mesic Typic Torrifluvents. Typic Torrifluvents were not included in the study by Dick-Peddie et al. (1987).

Trails soils are intermittently moist during periods from July to September and from December to February. These soils have a water table at 40 to 60 inches below the surface from April to October. The driest period occurs during May and June. The soil moisture regime is classified as Typic aridic.

The potential natural plant community on this unit is characterized by cottonwood, willows, New Mexico olive, and mesquite. The present vegetation is typically cottonwood, salt cedar, willow, Russian thistle (*Salsola iberica*), and camelthorn (*Alhagi pseudalhagi*).

Soil Salinity/Sodicity

Soil salinity/sodicity was the subject of an investigation by Hendrickx (1999). Hendrickx developed a soil potential rating that combines pH, electrical connectivity, sodium adsorption ratio and other criteria to rate salinity/sodicity problems. Soils with an index value of less than 25 represent soils of high restoration potential that will likely require no treatment or long-term salinity/sodicity management. Soils sampled at the restoration site had an index value of 10.5, indicating no need for corrective actions or any long-term management concerns (Hendrickx 1999).

VEGETATION

The Santa Ana Pueblo has been conducting an aggressive vegetation management program at the site, which until recently was dominated by Russian olive. The control program involves clearing aerial portions of the plants followed by root plowing, stacking and burning. The site has been cleared and root plowing will be completed in the near future. These activities adequately clear and grub the ground for future earthwork and planting.

DISCUSSION

Historic and current hydrologic, soil, and vegetative conditions point to an area historically supporting a bosque community dominated by cottonwood, willows, and other native riparian shrub species. On-site soils and the historic hydrologic regime do not indicate the past presence of open-water habitats or large areas of emergent wetland. Maps depicting dominant vegetation patterns in 1917 and 1935 tend to confirm this finding (DeRagon pers. comm, 2000).

While the site likely supported bosque and shrub habitats, current site conditions do not create insurmountable obstacles to creating either open-water or shrub wetlands.

DESIGN ALTERNATIVES

Two types of wetland complexes were studied for this project, each with three alternative designs. The first wetland complex is an open-water dominated wetland with ponds fringed with emergent and shrub vegetation (*open water wetland complex*). The second wetland complex is a shrub wetland without an open water component (*shrub wetland complex*).

In addition to the five overall goals for this project discussed above, specific goals were developed for each wetland design.

Open-water wetland complex

- Ponds with fringe of native wetland vegetation.
- Maximum interspersion of open water and vegetated habitats.
- Ponds would be at least one-foot deep during times of base flow.
- Maximum slope would be 6:1 (horizontal:vertical).
- Open water habitat occurs below elevation 5059 NGVD.
- Shrub habitat occurs between elevations 5,060 to 5,063 NGVD.
- Bosque habitat occurs between elevations 5,063 to 5,064 NGVD.

Shrub wetland complex

- Maximize interspersion with bosque habitats.
- No open water. Grade to a maximum depth of one-foot above high water table (elevation 5060 NGVD).
- Maximum slope would be 10:1 (horizontal:vertical).
- Shrub habitat occurs between elevations 5,060 to 5,063 NGVD.
- Bosque habitat occurs between elevations 5,063 to 5,064 NGVD.

Mosquito control

- Design should minimize potential for mosquitoes.
- Promote biologic control (e.g., *Gambusia* sp.) where appropriate.

Southwestern willow flycatcher habitat

- The ultimate success of the project is not dependent on attracting willow flycatcher, but habitat requirements could form the basis for design.
- Thickets of trees and shrubs (e.g. *Salix exigua*) with dense foliage.
- Plant diversity could be either low or high with mixtures of *Salix* and *Baccharis* under a cottonwood overstory providing 30 to 80 percent canopy coverage (Deragon pers. comm. 2000).
- Minimum patch size of 1.25 acres can support 1 or 2 nesting pairs.

Silvery minnow backwater habitat

- The ultimate success of the project is not dependent on attracting silvery minnow.
- Design must not trap silvery minnow or create mosquito habitat.
- Create habitat with little or no flow velocity (less than 10 cm/sec).
- Water depths should not be greater than 20 inches.
- Allow two-year flood event (5,800 cfs) to back up onto the site. This flow occurs at approximately elevation 5,060 NGVD.
- Allow 12 inches of water onto the site during the two-year event.
- Design to include “benches” along perimeter of backwater.
- No planting in backwater habitats.

With these design criteria in mind, three open water wetland and three shrub wetland designs were studied.

OPEN WATER WETLAND

The three open water wetland designs include:

1. A minimum wetland creation effort (about five acres).
2. A maximum wetland creation effort (about 10 acres).
3. A maximum wetland creation effort with backwater habitat added.

The acreage of habitat types created by the three open water wetland design scenarios is provided in Table 2.

Table 2 – Open Water Design Scenarios

Open Water Design Element	Scenario #1 (acres)	Scenario #2 (acres)	Scenario #3 (acres)
Open water wetland	3.0	6.0	6.0
Emergent wetland	0.3	0.7	0.7
Shrub wetland	1.7	3.6	3.6
Backwater habitat	0.0	0.0	0.7
Bosque	11.8	6.5	5.8
TOTAL	16.8	16.8	16.8

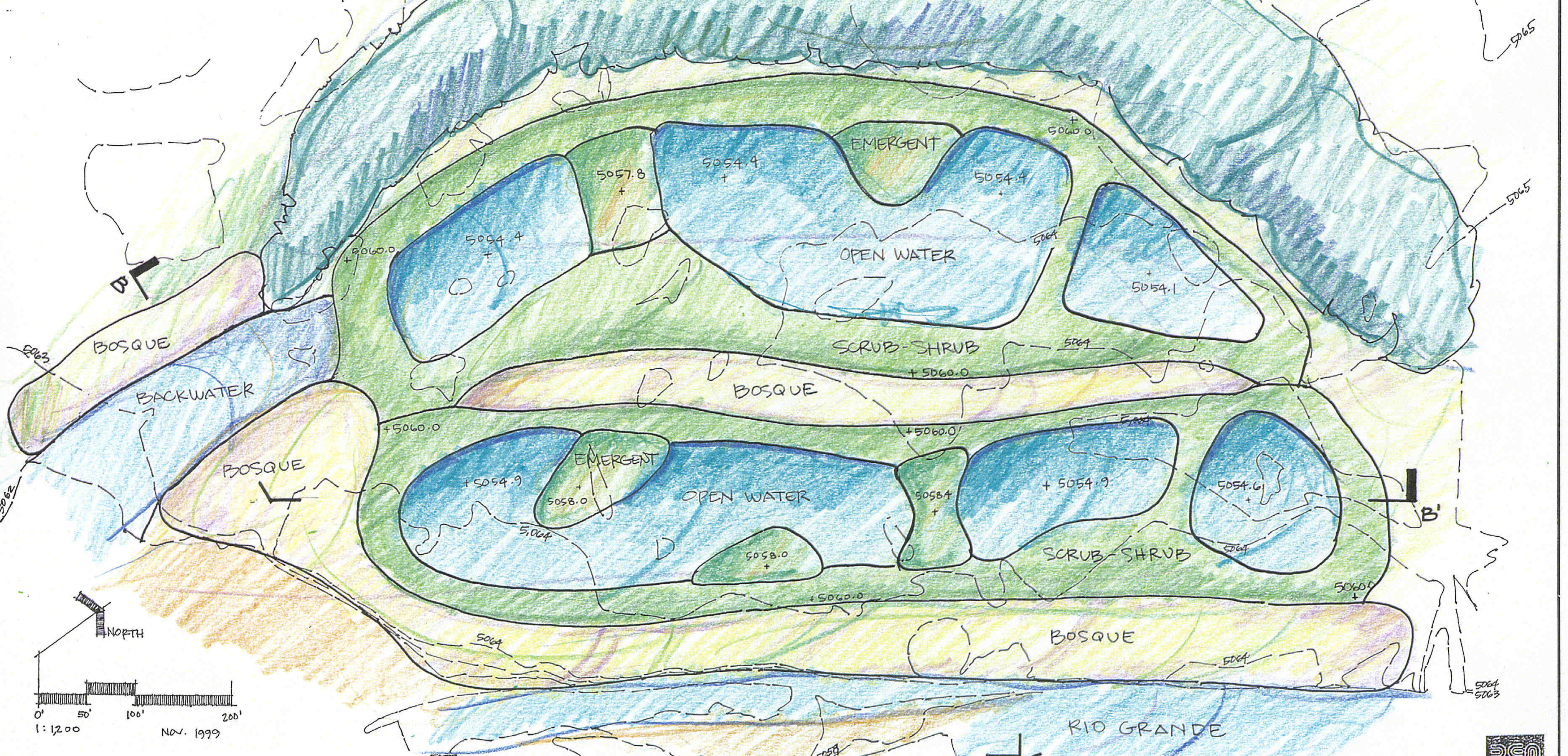
Design scenario 1 would create a series of three ponds in a north to south swale-like setting along the eastern edge of the restoration site. The northernmost pond would be graded slightly deeper than the others so that it could act as a sediment trap in the unlikely event of overbank flooding. The ponds would be irregularly shaped, interspersed with emergent and shrub habitats. The remainder of the site would be restored to a bosque plant community.

Design scenario 2 incorporates the design of scenario one and adds a second series of three ponds in a swale-like feature to the west. Again, the northernmost pond would be graded slightly deeper than the other two ponds

Design scenario 3 adds a 0.7-acre backwater habitat in the southeast corner of the site. The pond configuration for this scenario would be identical to design scenario two. The backwater habitat would be created out of what would be bosque habitat in either of the other two designs. Figures 1 and 2 illustrate open water design scenario three. Design scenario two is the same plan minus the backwater habitat. Scenario one is the same plan minus the backwater habitat and the western series of ponds.

QUANTITIES

BOSQUE	5.8 AC
BACKWATER	0.7 AC
SCRUB-SHRUB	3.6 AC
EMERGENT	0.7 AC
OPEN WATER	6.0 AC
EXCAVATION	124,100 CY



SCHEME 3
SANTA ANA PUEBLO WETLAND FEASIBILITY STUDY

SAPU-0002-0002

DAVID EVANS
AND ASSOCIATES, INC.
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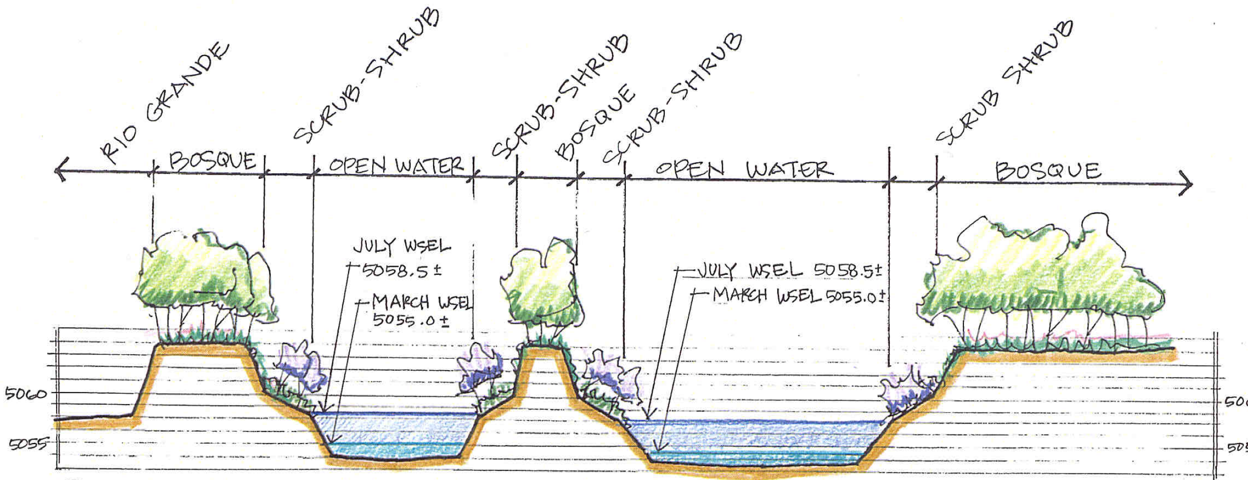
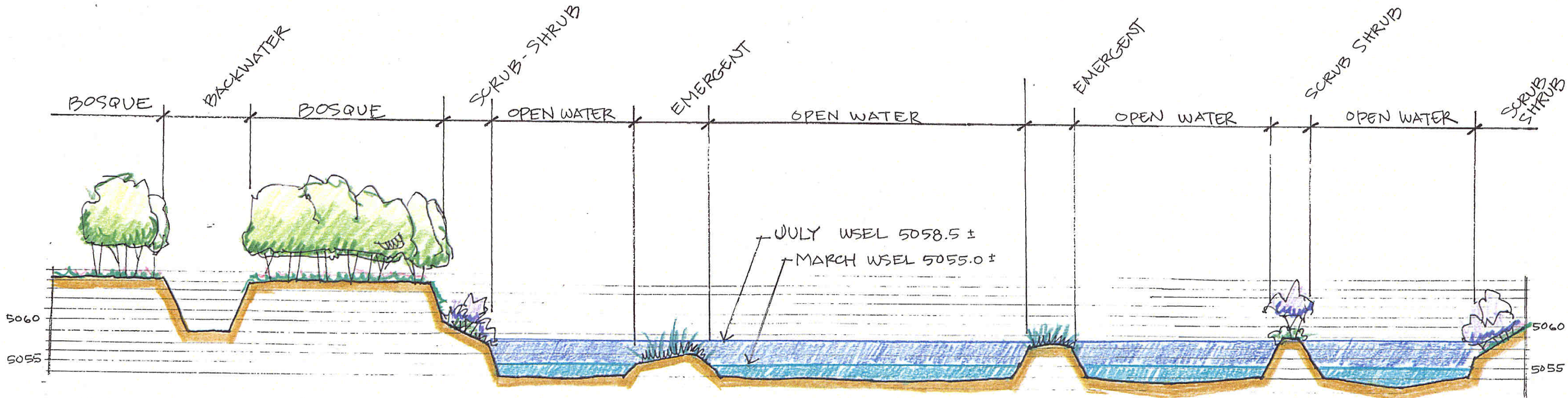
PORTLAND, OR. 97201-4830 (503) 223-6663



SECTION A-A'

H: 1" = 100' ; V: 1" = 10'



SECTION B-B'

H: 1" = 100' ; V: 1" = 10'

SECTIONS
SANTA ANA PUEBLO WETLAND FEASIBILITY STUDY

SAPU 0002-0002 NOV. 1999

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SHRUB WETLAND

Three shrub wetland designs mimicking the open water design scenarios were studied. These included

1. A minimum shrub wetland creation effort (about five acres)
2. A maximum shrub creation effort (about ten acres)
3. A maximum shrub wetland creation with backwater habitat added

The acreage of habitat types created by the three open water design scenarios is provided in Table 3.

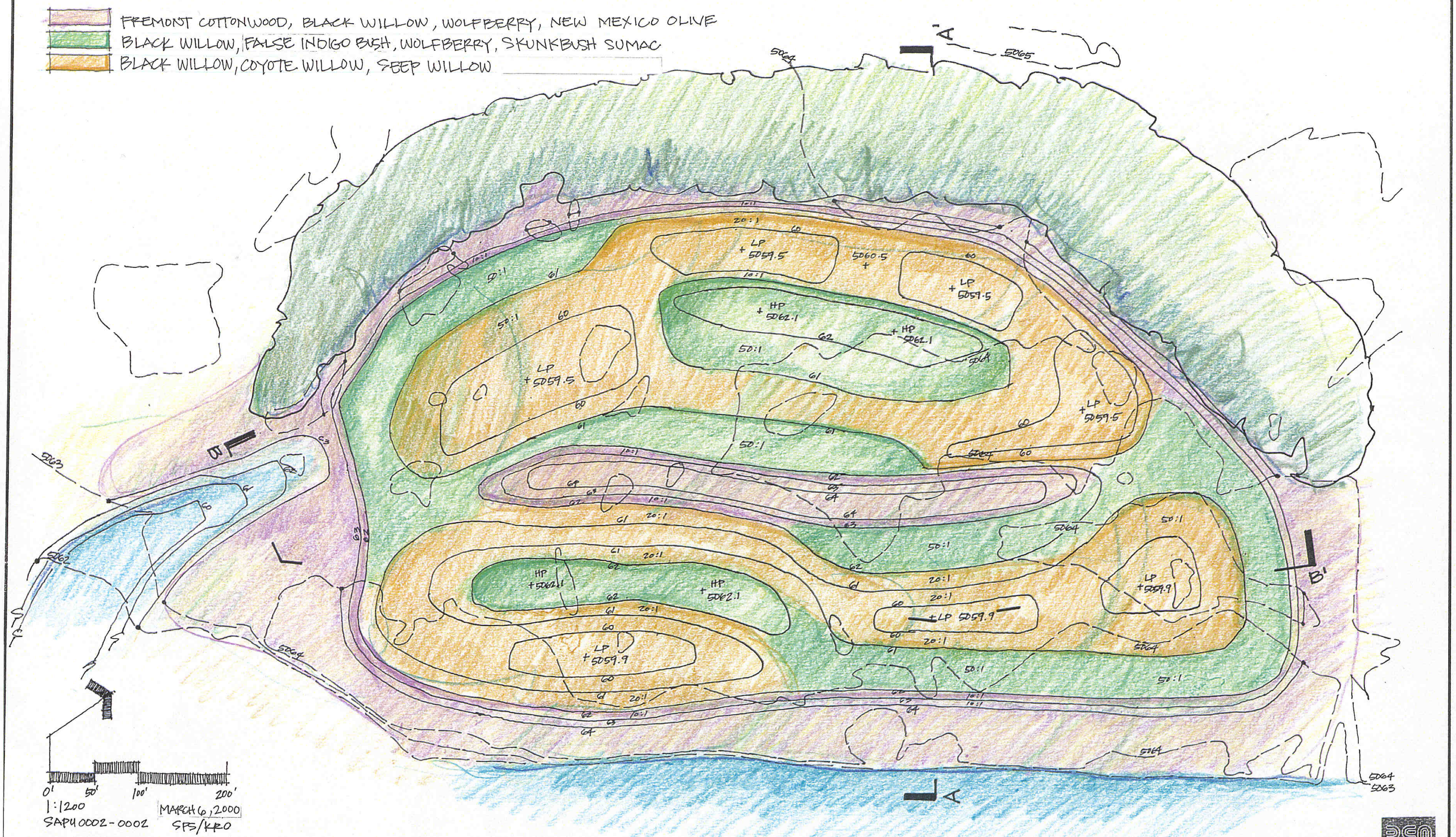
Table 3 – Shrub Design Scenarios

Design Element	Scenario #1 (acres)	Scenario #2 (acres)	Scenario #3 (acres)
Shrub	5.2	11.5	11.5
Bosque	11.6	4.7	4.0
Backwater	0.0	0.0	0.7
TOTAL	16.8	16.8	16.8

Shrub design scenario 1 would create shrub habitat in an elongated north to south swale along the eastern edge of the restoration site. The swale would be irregularly shaped, interspersed with restored bosque habitats. The swale would be graded to irregular depths, creating micro-habitats that would favor one species over another. Grading would be to a maximum depth of one foot above the expected high-water table. The remainder of the site would be restored to a bosque plant community.

Design scenario 2 incorporates the design of scenario one and adds a second shrub swale to the west.

Design scenario 3 adds a 0.7-acre backwater habitat in the southeast corner of the site. Shrub swale configuration would be identical to design scenario two. The backwater habitat would be created out of what would be bosque habitat in either of the other two designs. Figures 3 and 4 illustrate shrub design scenario three. Design scenario two is the same plan minus the backwater habitat. Scenario one is the same plan minus the backwater habitat and the western shrub dominated swale.



SCRUB-SHRUB WETLAND CONCEPT - PLAN

SANTA ANA PUEBLO WETLAND FEASIBILITY STUDY

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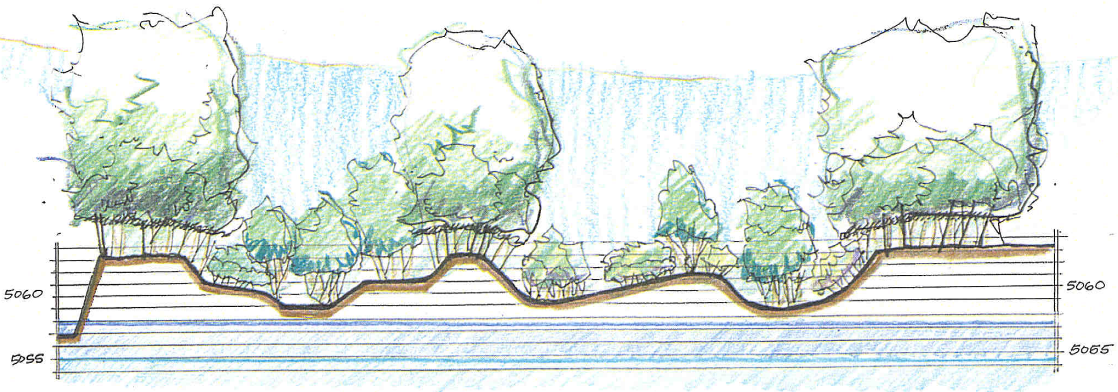

SECTION A-A'

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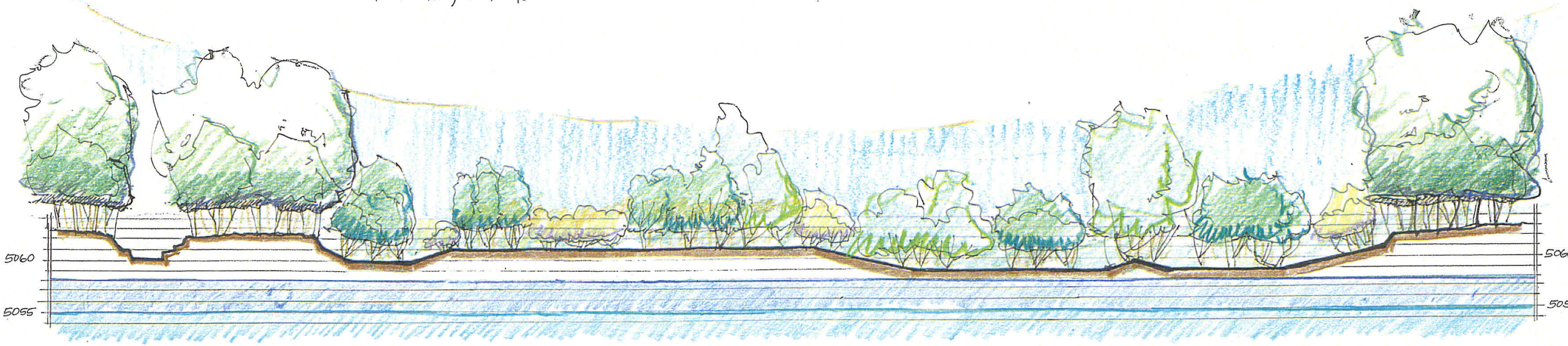

SECTION B-B'

H: 1" = 100'; V: 1" = 10'

SCRUB-SHRUB WETLAND CONCEPT - SECTIONS
SANTA ANA PUEBLO WETLAND FEASIBILITY STUDY

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HYDROLOGY

Hydrology is the critical, driving factor in wetland formation. Hydrology for this project will primarily be from groundwater. Based on available data (Santa Ana Pueblo 1999), groundwater elevations will range from approximately 5059 to 5056 NGVD, fluctuating approximately five to eight feet below the existing soil surface during the course of a typical year. Grading to these depths will create surface and near-surface hydroperiods sufficient to maintain open water habitats and hydrophytic vegetation within the wetland areas of the project. Wetland designs and cost estimates are based on the following groundwater depth assumptions.

- No change in groundwater depths as a result of constructing gradient restoration structure in the Rio Grande channel.
- Gradient restoration structures are placed preventing future degradation of the Santa Ana reach.
- Groundwater fed system only, with no overbank flows from the Rio Grande.
- Groundwater at peak flow is at elevations 5,058.5 to 5,059 NGVD (this occurs with flows in the Rio Grande at approximately 4,500 cfs).
- Groundwater at base flow is at elevations 5,054.5 NGVD (this occurs with flows in the Rio Grande at approximately 500 to 700 cfs).

VEGETATION

Plant species proposed for use in the restoration effort are native to the Middle Rio Grande region, adapted to riparian and wetland conditions (Table 4). Species would be grouped into bosque and shrub communities. Black willow and skunk-bush sumac would occur in both communities.

Table 4 – Plant Community Species List

Scientific Name	**Common Name**
Bosque	
Forestiera neomexicana	New Mexico olive
Lycium andersonii	wolfberry
Populus fremontii	Fremont cottonwood
Rhus aromatica var. *flabelliformis*	skunk-bush sumac
Salix nigra	black willow
Shrub Wetland	
Amorpa fruticosa var. *occidentalis*	false indigobush
Baccharis glutinosa	seepwillow
Salix nigra	black willow
Salix exigua	coyote willow

Fremont Cottonwood

Fremont cottonwood is a shade-intolerant species that colonizes exposed alluvium and other recently disturbed sites where groundwater is available during the growing season. It can occur in pure stands, but often grows in association with willows and other trees and shrubs. Cottonwoods are most successful on a deep, well-drained, medium-textured soil that has good moisture-holding capacity and/or where the water table is within reach.

Propagule Type and Spatial Distribution

Fremont cottonwood would be planted as pole cuttings. In order for the cuttings to reach the groundwater during the growing season (July), they must be placed in holes that are augered to the water table in at least six feet deep. Freemont cottonwood would be planted 30 feet apart (on average) (50 poles per acre) in areas depicted as bosque on the planting plan (above elevation 5,063 NGVD).

Skunk-Bush Sumac

Skunk-bush sumac is a variable, straggly to upright shrub that grows from 1.5 to 6.5 feet in height. It often occurs in dense thickets, providing good cover habitat. The fruit is palatable to many species of birds and mammals. Skunk-bush sumac is somewhat sensitive to flooding.

Propagule Type and Spatial Distribution

Skunk-bush sumac would be planted as a containerized shrub. As it is somewhat sensitive to flooding, it would be planted in areas not graded (bosque habitat) to areas three feet above the water table in July (elevation 5,064 to 5,061 NGVD). Plantings of this species would be grouped on 12-foot centers in order to create thickets.

New Mexico Olive

New Mexico olive is a sprawling, multi-branched shrub to six feet tall, or a small tree to ten feet tall. It is an important deer browse species. It has light-colored bark and light green leaves. New Mexico olive produces small yellow flowers in the spring, which are followed by dark blue fruit. Although regular deep monthly watering will produce a larger tree, the New Mexico olive can be drought-tolerant.

Propagule Type and Spatial Distribution

New Mexico olive would be planted as a containerized shrub. Plantings would be throughout the bosque habitats (elevations 5,064 to 5,061 NGVD).

False Indigobush

False indigobush is a deciduous shrub that grows to 10 feet tall. It has dark green pinately-compound leaves, each with up to ten pairs of oblong leaflets. Each leaflet is about two inches long. False indigobush produces small, deep violet-purple, one-petaled flowers in a slender spike that is up to seven inches long. The spike is borne in the leaf axil, and there are often two or three spikes per axil. These species is found along streamsides, canyons, and other moist locations.

Propagule Type and Spatial Distribution

False indigobush would be planted as a containerized shrub. Plantings would be limited to areas identified as bosque on the planting plan (elevations 5,060 to 5,063 NGVD).

Seepwillow

Seepwillow is a straggly shrub that grows to 10 feet tall. It is a rapid grower with a deep, fibrous root system, often forming dense thickets. It is found along streams and waterways.

Propagule Type and Spatial Distribution

Seepwillow would be planted as a containerized shrub. The distribution of this species in the project area would be limited the edges of shrub habitat (elevations 5,060 to 5,061 NGVD).

Black Willow

Black willow is the largest willow in the United States, reaching a height of 65 feet within thirty years. The species can grow up to 138 feet on some sites. It occurs along river margins, where it occupies the lower, wetter, and often less sandy sites. It flourishes at, or slightly below, the water table and is not appreciably damaged by flooding and silting. The species is shade-intolerant and often grows in dense, even-aged stands.

Propagule Type and Spatial Distribution

Black willow would be planted as pole cuttings. The length of the cutting depends on placement in planting plan (bosque versus shrub). Plantings would be grouped (on 12-foot centers) in order to create dense thickets. Black willow would be planted throughout the restoration site (elevations 5,060 to 5,064 NGVD).

Coyote Willow

Coyote willow is found almost exclusively in riparian habitat, marshy areas, alluvial terraces, and ditches. It characteristically forms a zone immediately adjacent to the water's edge. It can survive periodic inundation but must have portions of its root crown above the water table during the growing season. It is a shade-intolerant, pioneer species. It is often replaced by cottonwoods as they become established. Coyote willow can form thickets several meters thick, with densely spaced stems. These thickets provide cover and nesting habitat for small mammals and birds.

Propagule Type and Spatial Distribution

Coyote willow would be planted as whip cuttings. Coyote willow cuttings root along the entire length of the stem. It would to be planted throughout the shrub habitat (elevations 5,060 to 5,063 NGVD). Five whips would be installed at each planting site, creating a small willow clump. Plantings of individual clumps would be grouped on 12-foot centers to create dense thickets.

Wolfberry

Wolfberry is a spiny, rounded, multi-branched shrub that attains a height of one to nine feet. The species is drought deciduous, meaning it loses its foliage in response to drought. The root system is extensive, often extending 25 to 30 feet. Wolfberry occurs on hot, dry sites. Birds and mammals eat the showy red berries. In desert washes, wolfberry occurs in dense thorny thickets that provides good cover for quail and small wildlife.

Propagule Type and Spatial Distribution

Wolfberry would be planted as a containerized shrub on 12-foot centers to create dense thickets. Wolfberry plantings would be limited to areas identified as bosque on the planting plan (elevations 5,060 to 5,063 NGVD).

Planting Considerations

In the areas on the planting plan identified as bosque, cottonwood poles would be planted on 30-foot centers (50 poles per acre). Willow poles would be grouped in clumps by species. Plants within individual clumps would be installed on 12-foot centers, but the spacing between clumps would make the per acre average about 100 plants (20-foot centers).

Only willow pole cuttings and containerized shrubs would be installed in the areas on the planting plan identified as shrub habitat. These plantings would be grouped in clumps by species. Plants within clumps would be installed on 12-foot centers, but the spacing between individual clumps would make the per acre average about 150 (17-foot centers).

Pole cuttings will be used for Fremont cottonwood and black willow. Whips will be used for coyote willow. Whip cuttings will be collected nearby. The remainder of the species would be planted as containerized shrubs. While cottonwood cuttings would be widely spaced, black willow, coyote willow, seepwillow, skunk-bush sumac, and wolfberry would be planted at closer spacings in clumps to mimic the dense thickets these species often form.

Planting stock and planting techniques that maximize the root:shoot ratio are important considerations when planting in areas of high potential evapotranspiration. Containers (such as Treepots™) with greater depth relative to total volume should be used. Excessive aerial growth should be pruned prior to out-planting. Containerized stock should be planted in the fall in order to take advantage of both the fall and early spring root growth periods that occur while aerial portions of the plant are dormant. Root growth will occur when soil temperatures exceed 50 degrees Fahrenheit even though aerial portions of the plant are dormant. Fall planting in 2000 will require propagation of containerized plants no later than winter 1999-2000.

IRRIGATION SYSTEM

Due to the droughty nature of the site, an irrigation system would be very beneficial during the two-year plant establishment period. Two systems were examined for irrigating the installed plants: a drip irrigation system and an overhead impact type system. The advantages and disadvantages of each system are discussed below.

Drip Irrigation

Two drip irrigation systems were considered: one from a series of shallow, independent wells scattered throughout the project site, and the second from a centralized, larger and deeper well. The main concern regarding shallow well drip irrigation is that the filtration system must ensure that sand particles are not pulled into the drip lines. Sand particles can ultimately clog emitters and cause valves to "weep" or leak if not filtered properly. This is a far greater concern with shallow wells in soils such as those found on the project site, making a system of small shallow wells impractical due to increase maintenance requirements and the higher likelihood of individual system failures.

The drip irrigation system would consist of buried polyethylene pipe with one two-gallon-per-hour (gph) drip emitter installed adjacent each plant location. Small micro-tubing would extend from each buried drip emitter to the adjacent plant. The system would also include buried lateral poly-vinyl chloride (PVC) pipe from a buried mainline PVC pipe and dripline fittings, quick-coupling valves and valve boxes with small inline filters at each valve, and valve remote control wires.

Total installation cost is estimated at $34,500, which does not include establishing the water source (well), pump, POC filtration, or irrigation controller. This estimate includes all system materials for a system that would cover approximately 15 acres ($2,300/acre) and all labor for installing the system.

There are several benefits to drip systems compared to an overhead system. Drip systems have lower flow (gallons per minute) requirements from the water supply. A smaller water supply (pump) and shallower well depth would be required. Drip systems provide point source irrigation at each plant, eliminating potential runoff problems. Because water is delivered directly to a plant, weed establishment is greatly reduced between individual planting locations. Finally, drip irrigation systems have less expensive material and installation costs.

Conversely, drip irrigation systems have higher system maintenance requirements than overhead systems. They can be susceptible to wildlife damage (chewing). They have higher maintenance requirements for system filtration and higher requirements for inspection during system operation. Finally, there is an increased risk of plant failure if the system is not monitored for emitter clogging

Overhead Irrigation

A system utilizing overhead sprinkler irrigation requires a significant draw from the water table. This type of system demands high gallonage to operate several sprinklers per valve. The larger the radius of throw, the higher the gallons per minute (gpm) each sprinkler requires. If the radius of throw is reduced, there is an increase in the required number of sprinklers, valves, pipe, etc. An overhead impact sprinkler system requires a well established at a considerable distance into the water table due to draw requirements (gpm) and seasonal variations of the distance of the water table below the surface.

An overhead irrigation system would consist of an on-grade aluminum mainline pipe and on-grade aluminum supply laterals (rows spaced 40 feet on center), and valves and valve boxes. There would be a riser assembly for each sprinkler topped with brass impact sprinklers.

Overhead irrigation systems can be rented with an estimated cost of $9,750/year or $19,500 for the two-year plant establishment period. The above cost estimate includes all materials for a system that would cover approximately 15 acres and all labor for installing the system. It does not include establishing the water source (well), pump, POC filtration, transportation or irrigation controller.

Overhead systems are generally more durable than drip systems. They are subject to less wildlife damage and have easier maintenance and inspection requirements. However, a disadvantage is that higher flows (gpm) are required from the water supply, requiring a larger water supply (pump) with a greater well depth. Overhead systems irrigate areas without planted vegetation, resulting in higher weed establishment between planting locations and creating long-term maintenance issues. Runoff can be a problem, but site soils have such a high infiltration capacity that the chance of runoff problems is slight. The patterns of water delivery from an overhead system are often affected by winds, resulting in poor coverage and water shortages to some areas.

Discussion

A drip irrigation system is the recommended system for this project. While initial material and installation costs are higher than renting the material required for an overhead system, the smaller pump and shallower well requirements and the reduced water needs help to offset these costs. The main benefit of a drip system, however, is the direct application of water to individual plants. The greater potential for developing a weed problem with overhead systems, which would reduce the potential for achieving a self-sustaining native plant-dominated wetland with low maintenance requirements, justifies the higher costs for the drip system.

For the cost estimates discussed below, the drip irrigation system would only be used for bosque and shrub habitats with the open water wetland design. For the shrub wetland design, the entire site would be serviced by the irrigation system.

PLANT PROTECTION

Protecting plants from rabbit and beaver predation is an important consideration to the ultimate success of the project. Protection from beaver may be achieved by constructing a 48-inch tall hardware cloth or chicken-wire cage around each plant. The caging material should be secured to two one-half-inch rebar stakes or two-by-two wooden stakes driven into the ground on opposite sides of the plant. These structures typically cost about $3.00 each, installed. One cage would be constructed around each clumped coyote willow planting.

COSTS

Cost estimates are provided for constructing each of the six wetland designs. It is assumed that excavation would take place during times of base flow and would be accomplished with a belly-scraper. It is also assumed that the disposal site is nearby on property owned by the Santa Ana Pueblo. Excavators and haul trucks are not required. A cost of $3.00 per cubic yard was used in these calculations.

Pole cuttings are assumed to cost $22.00 each, installed. Collected whip cuttings cost $3.00 each, installed. Containerized plants would be one-gallon size and are assumed to cost $15.00 each, installed. It is assumed that emergent wetlands would be quickly colonized and would not be planted. Likewise, open water and backwater habitats would not be planted. Per-acre planting densities and costs by habitat type are provided in Table 5.

Table 5 – Per-Acre Planting Costs

Habitat	Plants	Cost
Scrub/Shrub	willow poles-75	$1,650.00
	willow whips-185	$555.00
	shrubs-75	$1,125.00
	335	$3,330.00
Bosque	cottonwood poles-50	$1,100.00
	willow poles-50	$1,100.00
	shrubs-50	$750.00
	150	$2,950.00

Cost estimates assume a drip irrigation system is installed, rather than an overhead impact sprinkler system.

OPEN WATER WETLAND

Excavation

Excavation quantities and costs are provided in Table 6.

Table 6 – Open Water Excavation Costs

Design Element	Scenario #1		Scenario #2		Scenario #3	
	Cu. Yds.	Cost	Cu. Yds.	Cost	Cu. Yds.	Cost
Wetland	57,300	$171,900	119,600	$358,800	119,600	$358,800
Backwater	0	$0	0	$0	4,500	$13,500
TOTAL	57,300	$171,900	119,600	$358,800	124,100	$372,300

Planting

Planting quantities and costs are provided in the Table 7.

Table 7 – Open Water Planting Costs

Design Element		Scenario #1		Scenario #2		Scenario #3	
		Amount	Cost	Amount	Cost	Amount	Cost
Shrub	p*	65	$1,430	137	$3,014	137	$3,014
	w	315	$945	666	$1,998	666	$1,998
	c	128	$1,920	270	$4,050	270	$4,050
Bosque	p	1,180	$25,960	650	$14,300	580	$12,760
	c	590	$8,850	325	$4,875	290	$4,350
Subtotal		2,278	$39,105	2,048	$28,237	1,943	$26,172
Protection		2,026	$6,078	1,515	$4,545	1,410	$4,230
TOTAL			$45,183		$32,782		$30,402

** p = pole cuttings   w = whip cuttings   c = containerized plant*

Total Cost

Total construction cost estimates for the three open water wetland designs are provided in Table 8. A ten percent mobilization cost and a ten percent contingency cost are included in the estimate.

Table 8 – Open Water Total Cost

Cost Item	Scenario #1	Scenario #2	Scenario #3
Excavation	$171,900	$358,800	$372,300
Planting	$45,180	$32,780	$30,400
Irrigation (drip)	$31,050	$23,230	$21,620
Subtotal	$248,130	$414,810	$424,320
Mobilization (10%)	$24,810	$41,480	$42,430
Contingency (10%)	$27,560	$45,630	$46,680
TOTAL	$300,500	$501,920	$513,430

SHRUB WETLAND

Excavation

Excavation quantities and costs are provided in Table 9.

Table 9 – Shrub Excavation Costs by Scenario

Design Element	Scenario #1		Scenario #2		Scenario #3	
	Cu. Yds.	Cost	Cu. Yds.	Cost	Cu. Yds.	Cost
Wetland	24,050	$72,150	44,100	$132,300	44,100	$132,300
Backwater	0	$0	0	$0	2,950	$8,850
TOTAL	24,050	$72,150	44,100	$132,300	47,050	$141,150

Planting

Total planting costs by scenario are provided in Table 10.

Table 10 – Shrub Planting Costs

Design Element		Scenario #1		Scenario #2		Scenario #3	
		Amount	Cost	Amount	Cost	Amount	Cost
Shrub	p*	195	$4,290	432	$9,504	432	$9,504
	w*	975	$2,925	2,155	$6,465	2,155	$6,465
	c*	390	$5,850	863	$12,945	863	$12,945
Bosque	p	1,160	$25,520	470	$10,340	400	$8,800
	c	580	$8,700	235	$3,525	200	$3000
Subtotal		3,300	$47,285	4,155	$42,779	4,050	$40,714
Protection		2,520	$7,560	2,431	$7,293	2,326	$6,978
TOTAL			$54,845		$50,072		$47,692

** p = pole cuttings   w = whip cuttings   c = containerized plant*

Total Cost

Total excavation and planting costs for the three shrub design alternatives are provided in Table 11.

Table 11 – Shrub Total Cost

Cost Item	Scenario #1	Scenario #2	Scenario #3
Excavation	$72,150	$132,300	$141,150
Planting	$54,850	$50,070	$47,690
Irrigation	$38,640	$38,640	$37,030
Subtotal	$165,640	$221,010	$225,870
Mobilization (10%)	$16,560	$22,100	$22,590
Contingency (10%)	$18,220	$24,310	$24,850
TOTAL	$200,420	$267,420	$273,310

MAINTENANCE

Maintenance efforts would be greatest during the first two years following planting. Efforts would be primarily directed toward the drip-irrigation system, checking the emitters to ensure that they are functioning properly and that individual plants are getting sufficient water. Plants that die would need to be replaced. Long-term maintenance would be primarily directed at controlling unwanted vegetation (e.g. salt cedar, Russian olive). The amount of effort required would be directly correlated to the degree of infestation.

DISCUSSION

Each of the design scenarios was rated as to how it achieved project goals and objectives discussed above. Each was judged as to whether it met, partially met, or did not meet project goals and objectives (Table 12).

Table 12 – Design Alternatives and Project Goals and Objectives

Design Criteria	Open Water Wetland			Shrub Wetland		
	# 1	#2	#3	# 1	#2	#3
Restore historic wetland habitats	●	●	●	●	●	●
Maximize wildlife values	○	◒	●	○	◒	◒
Self-sustaining/low maintenance	●	●	◒	●	●	◒
Minimize mosquito habitat	◒	○	○	●	●	●
Minimize hazards	◒	○	○	●	●	●
Creates willow flycatcher habitat	◒	●	●	◒	◒	◒
Creates silvery minnow habitat	○	○	●	○	○	●
Constructable	●	●	●	●	●	●
Cost effective	◒	◒	◒	◒	●	●

● = meets goals and objectives

◒ = partially meets goals and objectives

○ = does not meet goals and objectives

Both wetland designs restore historic wetland types largely lost in the Middle Rio Grande. Based on soil types present at the site, it is unlikely that the site ever supported ponds. Also, based on soil types and the work done by Dick-Peddie et al. (1987), there is a high likelihood that shrub wetlands did exist, if not on this site, then nearby. While open-water wetlands probably did not occur on-site, they historically occurred nearby (DeRagon pers. comm. 2000).

Open water designs maximize habitat types by including the open-water component which, by design, is lacking with the shrub designs. Both designs are interspersed with what would be restored bosque habitat. By virtue of incorporating ponds fringed with shrub vegetation, the open water wetlands create superior willow flycatcher habitat compared to the shrub designs. With the site being adjacent to the Rio Grande, open water is available nearby and the shrub designs would create habitat of some value.

Both the open water and shrub design scenario three create silvery minnow habitat. These designs are equal in their potential habitat value.

By virtue of creating ponds surrounded by vegetation, all three open water designs create mosquito habitat. Open water design one creates less mosquito habitat than designs two and three. With the Santa Ana resort just a short distance from the restoration site, all three of these designs create a nuisance for resort guests, thereby detracting from their recreational experience. The shrub designs specifically avoid an open water component, thereby not creating mosquito habitat. The backwater habitat would only hold water during high-water events (two-year flood and greater). The bottom would be graded to allow drainage as the water recedes, thus precluding its use by mosquitoes.

Also by virtue of creating ponds, the three open water designs create a hazard (drowning) for the resort guests, which increases the liability risk to the Santa Ana Pueblo. The shrub designs do not create a new hazard for resort guests.

Long-term maintenance issues should not be a concern for either design. There is a possibility that silt may build up in the mouth of the backwater habitat, requiring occasional grading to maintain the open water connection. Should silt deposition occur and not be removed, there is the potential to trap silvery minnow as the waters recede. There is also a potential that vegetation (cattails, bulrushes) may spread throughout the ponds. Depth of the year-round open water should prevent this, but should it occur, and an open water component still be desired, then maintenance work (i.e. dredging) would be required.

The amount of earth needed to be excavated to create permanent open water ponds greatly increases project costs compared to the shallower excavation required for the shrub wetland. Significantly greater areas can be restored on a dollar per dollar basis when the goal is to restore shrub habitat rather than to create open water ponds.

Clearly there are conflicts within the criteria (e.g. maximize habitat types while minimizing mosquito habitat). Inherently, a design that maximizes habitat types by creating natural ponds surrounded by vegetation will also create mosquito habitat. To minimize mosquito habitat the ponds would have to be deep, with steep sides and be void of vegetative cover. This type of design would decrease habitat values while increasing the risk to resort guests.

Shrub wetland scenario three, which restores 11.5 acres of shrub wetland and 5.5 acres of bosque habitat while creating 0.7 acres of silvery minnow backwater habitat, is the only scenario of the six studied that meets or partially meets all design criteria. It does not create a mosquito problem, nor does it expose the Santa Ana Pueblo or the resort guests to increased risk. While it does not maximize habitat types relative to the open water designs, it does restore a native wetland type currently lacking in the immediate vicinity in a cost-effective manner. Shrub wetland scenario three is the recommended restoration design. This design could very easily be expanded beyond the 17-acre site currently under consideration. The estimated cost for this design scenario is $273,310. The Santa Ana Pueblo own a considerable amount of land with similar characteristics to those described in this report that would be suitable for this kind of restoration effort.

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WETLAND INDICATOR STATUS

The US Fish and Wildlife Service (USFWS) has classified vegetation according to its frequency of occurrence in wetlands (USFWS, 1996). Plant species have been given wetland indicator status of either obligate wetland (OBL), facultative wetland (FACW), facultative (FAC), facultative upland (FACU), or upland (UPL) based on their probabilities for occurring in wetlands. For each of the three facultative plant indicator categories a plus (+) sign denotes an affinity of a particular species for a slightly more hydrophytic habitat. Similarly, a minus (-) sign indicates a preference for a less hydrophytic habitat.

Table 13 - Plant Indicators Used To Determine Wetland Status

Indicator Symbol	Indicator Status	Definition
OBL	Obligate	Species that occur almost always (estimated probability >99%) in wetlands under natural conditions.
FACW	Facultative wetland	Species that occur in wetlands (estimated probability 67 to 99%), but occasionally are found in non-wetlands.
FAC	Facultative	Species that are equally likely to occur in wetlands or non-wetlands (estimated probability 34-66%).
FACU	Facultative upland	Species that usually occur in non-wetlands (estimated probability 67-99%), but occasionally are found in wetlands.
UPL	Upland	Species that occur almost always in non-wetlands under normal conditions (estimated probability >99%).
NI	No indicator	Species for which insufficient information was available to determine an indicator status.

Source: *1996 National List of Vascular Plant Species that Occur in Wetlands (USFWS 1996).*

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